

## CHAPTER 6. OCCUPATIONAL EXPOSURES

This chapter presents data on occupational exposures from several sources. Data from compliance samples obtained by MSHA inspectors are presented in table 6-1 for coal mine dust and silica dust, and in tables 6-2 through 6-6 for metal fumes. Since these samples were taken for compliance monitoring rather than as part of a survey of the industry, it is difficult to predict how well they indicate actual exposures for all mining operations.

In the coal industry, 7.8% of all respirable dust samples during 1986-1995 were above the permissible exposure limit (PEL). Of silica dust samples obtained during the 10-year period, 23.7% were above the PEL in coal, 16% in metal, 10.8% in nonmetal, 9.1% in stone, and 7.6% in sand and gravel. Of metal fume samples, silver samples showed the largest percentage above the PEL—approximately 48% of samples in both metal and nonmetal.

Tables 6-7 and 6-8 present data on noise exposures from the MSHA “dual threshold” survey, which was published in the *Federal Register* [61 Fed. Reg. 66347 (1996)] as part of a proposed rule change for occupational noise exposure in mining. This study examined a group of samples obtained

during 1991-1995 and compared the percent of samples that were above two separate specified limits. The first limit was the current noise standard, a time-weighted average of 90 dBA, calculated to include only exposures at 90 dBA and above. The second limit was a time-weighted average of 85 dBA, calculated to include exposures at 80 dBA and above.

Tables 6-8 and 6-9 refer to musculoskeletal overload conditions examined in the National Occupational Health Survey of Mining (NOHSM) [NIOSH 1996]. Table 6-8 shows the operational definitions for each condition; table 6-9 shows the percentage of the workforce potentially exposed, by commodity. Across all commodities, a large proportion of workers were exposed to musculoskeletal overloads due to positioning of the neck and back; positioning and motion of the forearms, arms, and shoulders; heavy lifting; and positioning and movement of the lower limbs.

The recorded overloads were defined in the survey and did not exceed any NIOSH, MSHA, or OSHA guidelines for musculoskeletal overloads. Further information on this survey appears in appendix A.

**Table 6-1.—Dust samples, 1986-1995. Number of samples, number and percent under permissible exposure limit (PEL), number and percent 1-2 times PEL, and number and percent 2 or more times PEL.**

Sample type	Total samples	Samples under PEL		Samples > PEL and <2 × PEL		Samples ≥2 × PEL	
		No.	%	No.	%	No.	%
Coal respirable dust	194,682	179,584	92.2	11,751	6.0	3,347	1.7
Coal silica dust	49,044	37,434	76.3	7,213	14.7	4,397	9.0
Metal silica dust	9,044	7,593	84.0	873	9.7	578	6.4
Nonmetal silica dust	10,347	9,230	89.2	668	6.4	449	4.3
Stone silica dust	45,608	41,453	90.9	2,435	5.3	1,720	3.7
Sand and gravel silica dust	34,924	32,275	92.4	1,487	4.3	1,162	3.3

Source: Mine Safety and Health Administration data.

**Table 6-2.—Metal industry: metal fume samples, 1986-1995. Number of samples, number and percent under permissible exposure limit (PEL), number and percent 1-2 times PEL, and number and percent 2 or more times PEL.**

Fume type	Total samples	Samples < PEL		Samples > PEL and < 2 × PEL		Samples > 2 × PEL	
		Number	Percent			Number	Percent
Aluminum oxide	778	776	99.7	0	0.0	2	0.3
Arsenic	379	379	100.0	0	0.0	0	0.0
Beryllium	465	464	99.8	1	0.2	0	0.0
Cadmium oxide	495	494	99.8	0	0.0	1	0.2
Chromic acid/chromate	444	419	94.4	15	3.4	10	2.3
Cobalt	483	481	99.6	0	0.0	2	0.4
Copper	858	812	94.6	16	1.9	30	3.5
Fluoride	4	4	100.0	0	0.0	0	0.0
Iron oxide	1,038	1,008	97.1	13	1.3	17	1.6
Lead	797	757	95.0	22	2.8	18	2.3
Magnesium oxide	743	743	100.0	0	0.0	0	0.0
Manganese	793	793	100.0	0	0.0	0	0.0
Mercury	156	137	87.8	10	6.4	9	5.7
Molybdenum	453	452	99.8	1	0.2	0	0.0
Nickel	559	559	100.0	0	0.0	0	0.0
Silver	248	129	52.0	25	10.1	94	37.9
Titanium dioxide	602	601	99.8	1	0.2	0	0.0
Vanadium	512	511	99.8	1	0.2	0	0.0
Zinc oxide	698	697	99.9	1	0.1	0	0.0

Source: Mine Safety and Health Administration data.

**Table 6-3.—Nonmetal industry: metal fume samples, 1986-1995. Number of samples, number and percent under permissible exposure limit (PEL), number and percent 1-2 times PEL, and number and percent 2 or more times PEL.**

Fume type	Total	Samples < PEL		Samples > PEL and < 2 × PEL		Samples > 2 × PEL	
		Number	Percent	Number	Percent	Number	Percent
Aluminum oxide	2,460	2,454	99.8	2	0.1	4	0.2
Arsenic	1,309	1,309	100.0	0	0.0	0	0.0
Beryllium	1,550	1,547	99.8	3	0.2	0	0.0
Cadmium oxide	1,513	1,512	99.9	1	0.1	0	0.0
Chromic acid/chromate	1,467	1,297	88.4	65	4.4	105	7.2
Cobalt	1,609	1,607	99.9	2	0.1	0	0.0
Copper	2,453	2,378	96.9	29	1.2	46	1.9
Iron oxide	3,220	3,148	97.8	39	1.2	33	1.0
Lead	1,941	1,898	97.8	25	1.3	18	0.9
Magnesium oxide	2,555	2,555	100.0	0	0.0	0	0.0
Manganese	2,824	2,761	97.8	40	1.4	23	0.8
Mercury	113	94	83.2	10	8.8	9	8.0
Molybdenum	1,532	1,531	99.9	1	0.1	0	0.0
Nickel	1,974	1,967	99.6	4	0.2	3	0.2
Silver	249	130	52.2	25	10.0	94	37.8
Tin oxide	3	3	100.0	0	0.0	0	0.0
Titanium dioxide	2,182	2,181	100.0	1	0.0	0	0.0
Vanadium	1,593	1,590	99.8	3	0.2	0	0.0
Zinc oxide	2,099	2,097	99.9	2	0.1	0	0.0

Source: Mine Safety and Health Administration data.

**Table 6-4.—Stone industry: metal fume samples, 1986-1995. Number of samples, number and percent under permissible exposure limit (PEL), number and percent 1-2 times PEL, and number and percent 2 or more times PEL.**

Fume type	Total samples	Samples < PEL		Samples > PEL and < 2 × PEL		Samples > 2 × PEL	
		Number	Percent	Number	Percent	Number	Percent
Aluminum oxide	1,164	1,162	99.8	1	0.1	1	0.1
Arsenic	538	538	100.0	0	0.0	0	0.0
Beryllium	666	666	100.0	0	0.0	0	0.0
Cadmium oxide	619	619	100.0	0	0.0	0	0.0
Chromic acid/chromate	795	667	83.9	44	5.5	84	10.6
Cobalt	704	704	100.0	0	0.0	0	0.0
Copper	1,065	1,044	98.0	9	0.8	12	1.1
Iron oxide	1,512	1,478	97.8	20	1.3	14	0.9
Lead	708	705	99.6	3	0.4	0	0.0
Magnesium oxide	1,254	1,254	100.0	0	0.0	0	0.0
Manganese	1,424	1,367	96.0	37	2.6	20	1.4
Mercury	6	6	100.0	0	0.0	0	0.0
Molybdenum	664	663	99.8	1	0.2	0	0.0
Nickel	967	961	99.4	3	0.3	3	0.3
Silver	1	1	100.0	0	0.0	0	0.0
Tin oxide	3	3	100.0	0	0.0	0	0.0
Titanium dioxide	1,085	1,084	99.9	1	0.1	0	0.0
Vanadium	688	686	99.7	2	0.3	0	0.0
Zinc oxide	950	948	99.8	2	0.2	0	0.0

Source: Mine Safety and Health Administration data.

**Table 6-5.—Sand and gravel industry: metal fume samples, 1986-1995. Number of samples, number and percent under permissible exposure limit (PEL), number and percent 1-2 times PEL, and number and percent 2 or more times PEL.**

Fume type	Total samples	Samples < PEL		Samples > PEL and < 2 × PEL		Samples > 2 × PEL	
		Number	Percent			Number	Percent
Aluminum	346	346	100.0	0	0.0	0	0.0
Arsenic	240	240	100.0	0	0.0	0	0.0
Beryllium	254	252	99.2	2	0.8	0	0.0
Cadmium oxide	250	250	100.0	0	0.0	0	0.0
Chromic acid/chromate	144	136	94.4	3	2.1	5	3.5
Cobalt	264	264	100.0	0	0.0	0	0.0
Copper	325	322	99.1	2	0.6	1	0.3
Iron oxide	432	427	98.8	3	0.7	2	0.5
Lead	271	271	100.0	0	0.0	0	0.0
Magnesium oxide	338	338	100.0	0	0.0	0	0.0
Manganese	387	386	99.7	1	0.3	0	0.0
Mercury	2	2	100.0	0	0.0	0	0.0
Molybdenum	247	247	100.0	0	0.0	0	0.0
Nickel	280	280	100.0	0	0.0	0	0.0
Titanium dioxide	321	321	100.0	0	0.0	0	0.0
Vanadium	250	250	100.0	0	0.0	0	0.0
Zinc oxide	303	303	100.0	0	0.0	0	0.0

Source: Mine Safety and Health Administration data.

**Table 6-6.—Coal industry: MSHA “dual-threshold” study, 1991-1995. Number of samples by occupation, percent of samples over 90 dBA based on 90-dBA threshold for time-weighted average, and percent of samples over 85 dBA based on 80-dBA threshold for time-weighted average.**

Occupation	Number of samples	% of samples over 90 dBA with time-weighted average based on 90-dBA threshold	% of samples over 85 dBA with time-weighted average based on 80-dBA threshold
Continuous miner helper	68	33.8	98.2
Continuous miner operator	262	49.6	96.2
Roof bolter operator (single)	234	21.8	95.5
Roof bolter operator (twin)	92	31.5	98.9
Shuttle car operator	260	13.5	78.5
Scoop car operator	94	18.1	74.5
Cutting machine operator	22	36.4	63.6
Headgate operator	20	40.0	100.0
Longwall operator	34	70.6	100.0
Jack setter (longwall)	25	32.0	68.0
Cleaning plant operator	107	36.4	77.6
Bulldozer operator	225	48.9	94.2
Front-end loader operator	244	16.0	76.6
Highwall drill operator	83	21.7	77.1
Refuse/backfill truck driver	162	13.6	78.4
Coal truck driver	28	17.9	64.3

**Table 6-7.—Metal/nonmetal industry: MSHA “dual-threshold” study, 1991-1994. Number of samples by occupation, percent of samples over 90 dBA based on 90-dBA threshold for time-weighted average, and percent of samples over 85 dBA based on 80-dBA threshold for time-weighted average.**

Occupation	Number of samples	% of samples over 90 dBA with time-weighted average based on 90-dBA threshold	% of samples over 85 dBA with time-weighted average based on 80-dBA threshold
Front-end loader operator	12,812	12.9	67.7
Truck driver	6,216	13.1	73.7
Crusher operator	5,357	19.9	65.1
Bulldozer operator	1,440	50.7	86.5
Bagger	1,308	10.2	65.0
Sizing/washing plant operator	1,246	13.2	59.7
Dredge/barge attendant	1,124	27.2	78.7
Clean-up person	927	19.3	71.3
Dry screen operator	871	11.7	57.6
Utility worker	848	12.4	60.6
Mechanic	761	3.6	43.9
Supervisors/administrators	730	9.0	32.2
Laborer	642	17.1	65.7
Dragline operator	583	34.0	82.5
Backhoe operator	546	8.4	52.6
Dryer/kiln operator	517	10.5	55.5
Rotary drill operator (electric/hydraulic)	543	39.6	83.1
Rotary drill operator (pneumatic)	489	64.4	89.0

**Table 6-8.—Operational definitions for musculoskeletal overload conditions in the National Occupational Health Survey of Mining (NOHSM).**

Awkward lifting	Lifting above head level, or lifting while twisting, or lifting while reaching excessively.
Heavy lifting	Lifting greater than 50 lb unaided.
Frequent lifting	Lifting an object heavier than 25 lb, 5 or more times per minute.
Fingers and hands	Forceful finger actions (except grasping with the whole hand), grasping with wet or poorly fitting gloves, tool handles that end in the central part of the palm.
Wrist movement	Forceful movements or finger manipulations with wrist bent, using repeated wrist motions, or clothes-wringing motion.
Forearms, arms, and shoulders	Elbows unsupported and/or abducted, or forearms resting on sharp edges, or working with hands above the shoulders, or tossing motions at extremes of range of motion.
Neck and/or back	Bent forward, or bent to the side, or hyperextended, or twisted neck and back.
Lower limb movement	Kneeling, or squatting (bearing the body weight on the knee, flexed to an acute angle), or crawling on hands and knees.
Sitting	Sitting in a cramped position, or with feet dangling, or without low back support, or in a seat tilted forward or to one side.
Standing	Standing without movement for 4 or more min or operating foot pedals while standing, or standing in a restricted space for 2 hr or more without sitting or leaning.
Prone or supine	Lying flat on back, or lying on abdomen, or lying on one side supported by one hip and one shoulder or elbow.



**Table 6-9.—Percent of workers potentially exposed to musculoskeletal overload conditions by condition and commodity, National Occupational Health Survey of Mining (NOHSM), 1984-1989.**

Musculoskeletal overload condition	Percentage of workforce potentially exposed				
	Coal	Metal	Nonmetal	Stone	Sand and Gravel
Awkward lifting	22	29	16	17	19
Heavy lifting	41	37	24	30	21
Frequent lifting	9	3	8	8	5
Fingers and hands	24	35	24	14	12
Wrist movement	21	29	16	12	11
Forearms, arms, and shoulders	44	39	30	25	23
Neck and/or back	42	50	35	34	30
Lower limb movement	31	26	15	16	13
Sitting	19	10	8	9	11
Standing	<1	2	3	1	4
Prone or supine	10	5	5	4	3

## REFERENCES

- 61 Fed. Reg. 66347-66397 [1996]. Mine Safety and Health Administration: 30 CFR Parts 56, 57, 62, 70, and 71, health standards for occupational noise exposure in coal, metal, and nonmetal mines; proposed rule.
- Franks JR [1996]. Analysis of audiograms for a large cohort of noise-exposed miners. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Biomedical and Behavior Science.
- Franks JR [1997]. Prevalence of hearing loss for noise-exposed metal/nonmetal miners. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Division of Biomedical and Behavior Science.
- MSHA [1997]. Injury experience in coal mining, 1996. Denver, CO: U.S. Department of Labor, Mine Safety and Health Administration, Office of Injury and Employment Information, IR 1253, pp. 5-7.
- NIOSH [1996]. Results from the National Occupational Health Survey of Mining (NOHSM). Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 96-136.
- Office of Management and Budget [1987]. Standard industrial classification manual. Washington, DC.
- U.S. Bureau of the Census [1982]. 1980 census of population, alphabetic index of industries and occupations. Washington, DC: U.S. Department of Commerce, Bureau of the Census, publication PHC80-R3.
- U.S. Bureau of Labor Statistics [1995]. Fatal workplace injuries in 1993: a collection of data and analysis. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, report 891.
- World Health Organization [1977]. International classification of diseases: manual on the international statistical classification of diseases, injuries, and causes of death. 9th rev. Geneva, Switzerland.